

Maple Syrup: Measuring Density

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Factsheet

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The density of maple syrup is a measurement of the percentage of dissolved solids, which includes sugars and minerals. However, sugar accounts for about 98% of the dissolved solids in the syrup. Therefore, by measuring the density as a reading of dissolved solids, a reasonably accurate estimate of the percentage of sugars in the syrup can be made. In general, the density of maple syrup is measured with a hydrometer, a hydrotherm or a refractometer.

Maple syrup can only be legally offered for sale if it has a density of at least 66% sugar (66°Brix). To obtain this minimum density, the syrup should be boiled until it reaches a temperature of 3.94°C (7.10°F) above the boiling point of water (Table 1). Syrup with densities of 66.5°Brix–67.5°Brix has a more pronounced maple flavour and a better palatability because of its increased viscosity. These densities will be reached at temperatures of 4.06°C–4.28°C (7.30°F–7.70°F) above the boiling point of water.

Table 1. Degrees over the boiling point of water necessary to reach permissible and optimum maple syrup density.

Temperature over boiling point of water		Maple syrup density	
°C	(°F)	% sugar (Brix)	
3.94	(7.10)	66.00	minimum density
4.00	(7.20)		
4.06	(7.30)	66.50	
4.07	(7.34)	66.60	
4.10	(7.38)	66.70	
4.11	(7.40)	66.75	
4.14	(7.46)		
4.17	(7.50)	67.00	optimum density range
4.19	(7.54)	67.10	
4.21	(7.58)	67.20	
4.23	(7.62)	67.30	
4.26	(7.66)	67.40	
4.28	(7.70)	67.50	

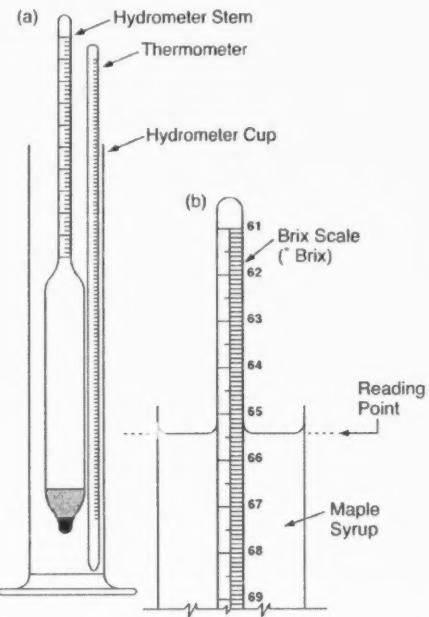


Figure 1. Hydrometer assembly showing the assembly parts (a) and the flotation level of the hydrometer when lowered in the maple syrup (b). **Note:** The reading point should be level with the line surface of the syrup in the cup. In this case, the reading is 65.4°Brix.

THE HYDROMETER

Hydrometers are most generally used for measuring the density of maple syrup. The hydrometer assembly consists of a hydrometer, a thermometer and a hydrometer cup (Figure 1a). The density of the syrup in percent solids can be read directly from the Brix scale on the hydrometer stem (Figure 1b).

The accuracy of the hydrometer readings depends on the spacing of the markings on the Brix scale on the hydrometer stem, which in turn depends on the diameter of the stem. Thus the thinner the stem, the further apart the markings and the greater the accuracy of the density measurements. The Brix scale on the hydrometer stem is normally calibrated at a temperature of 20°C (68°F). Some maple producers use a 15.5°C (60°F) hydrometer that would have a different temperature correction factor. To make exact density measurements of maple syrup, use a hydrometer that has a scale with 0.1°Brix graduations or markings (Figure 1b).



Figure 2. The observed Brix value can be read directly on the Brix scale on the hydrometer stem.

Measuring the density

Measuring the density of maple syrup with a hydrometer is relatively simple. The hydrometer cup is filled with maple syrup as close as possible to the top. Allowing space at the top of the cup may produce a reading angle that is too severe to ensure accuracy, particularly on a short-stemmed hydrometer. Gently lower the clean, dry hydrometer into the syrup inside the cup. The hydrometer will sink to a level at which it will float. The observed Brix value can be read on the Brix scale (Figure 2).

The temperature of the syrup is determined by lowering a 15-cm long stem thermometer into the syrup alongside the hydrometer. If the syrup has a temperature of 20°C (68°F), the observed Brix reading will be the true density value. If the syrup has a temperature higher than 20°C, the syrup is thinner and the hydrometer has sunk deeper into the syrup. The observed density (Brix value) will be less than its true density (Brix value), and corrections must be made to the observed reading to obtain true density values.

Table 2. Corrections to apply to observed Brix readings of maple syrup to compensate for effects of temperature.

Syrup Temperature (Hydrometer Cup or Refractometer)		Correction: subtract (-) or add (+)	Syrup Temperature (Hydrometer Cup or Refractometer)		Correction: subtract (-) or add (+)
°C	°F		°C	°F	
0	32	-1.4	34	93	1.1
2	36	-1.3	35	95	1.2
4	39	-1.2	36	97	1.3
6	43	-1.1	37	99	1.3
8	46	-1.0	38	100	1.5
10	50	-0.8	39	102	1.6
11	52	-0.7	40	104	1.7
12	54	-0.6	41	106	1.7
13	55	-0.5	42	108	1.8
14	57	-0.4	43	109	1.9
15	59	-0.4	44	112	2.0
16	61	-0.3	45	113	2.1
17	63	-0.2	46	115	2.2
18	64	-0.1	47	117	2.3
19	66	-0.1	48	118	2.3
20*	68	0	49	120	2.4
21	70	0.2	50	122	2.5
22	72	0.3	52	125	2.7
23	73	0.3	54	130	3.0
24	75	0.3	56	133	3.2
25	77	0.4	58	136	3.3
26	79	0.5	60	140	3.5
27	81	0.5	62	144	3.7
28	82	0.7	64	147	3.9
29	84	0.8	66	150	4.1
30	86	0.9	68	155	4.4
31	88	0.9	70	158	4.6
32	90	1.0	72	162	4.8
33	91	1.1	74	165	5.0

* Most hydrometers and refractometers are calibrated at exactly 20°C.

Likewise, if the syrup has a temperature less than 20°C, the syrup is thicker and the hydrometer has sunk less deep into the syrup. The observed density (Brix value) will be greater than its true density, and the corrections must be made again in order to obtain the true density values. Table 2 shows the correction values to be added or subtracted from the observed reading to obtain the true density value.

Caution When lowering the hydrometer into the syrup, do not allow it to sink below its floating position and rise. Syrup on the exposed part of the stem would add weight and cause the hydrometer to sink too deep, resulting in inaccurate (too low) readings.



Figure 3. The true density measurements of maple syrup depend on the syrup's temperature. The observed density reading has to be adjusted according to the temperature correction (Table 2).

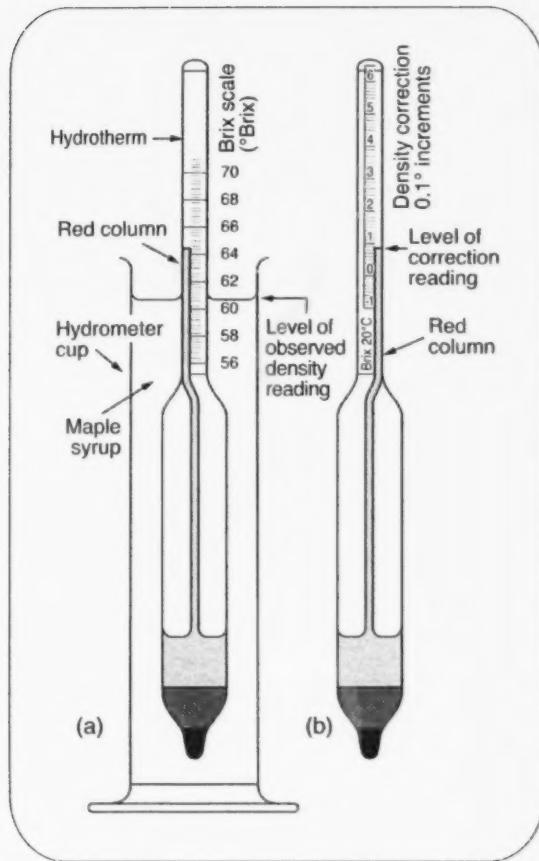


Figure 4. Hydrotherm assembly: (a) the assembly parts and the level of density reading; (b) correction reading.

THE HYDROTHERM

The hydrotherm is an instrument that combines the hydrometer and the thermometer into one measuring unit. The actual density of the syrup being measured can be determined directly by reading the two scales on the stem: (a) the Brix scale in 0.2°Brix markings; and (b) the density correction scale in 0.1° markings. Many hydrotherms do not have a numerical scale on them, and some do not have a separate correction scale.

Measuring the density

The clean, dry hydrotherm is gently lowered into the syrup in the cup. The observed density is read from the Brix scale on the hydrotherm's stem at the flotation level, for example 65.8°Brix (Figure 4a). The Density Correction is read at the top of the red column on the Density Correction Scale on the reverse side of the stem, for example +0.8 (Figure 4b). The

true density reading of this syrup sample being tested is, therefore, $65.8 + 0.8 = 66.6$ °Brix.

Maintenance of hydrometers and hydrotherms

When Instruments are not In use:

Keep the hydrotherm in an upright position to prevent the red column from separating. Should the red column separate, heat the hydrotherm to 90°C (210°F) and then, holding the hydrotherm in one hand, slap the hand holding the hydrotherm vigorously on the palm of the other hand. **Note:** Do not hit the hydrotherm!

When Instruments are In use:

Keep the hydrometer and hydrotherm upright in hot water or in hot syrup at a temperature close to that of the syrup to be tested. This will avoid the delay in obtaining a correct temperature compensation reading.

Before using the hydrometer or hydrotherm, wipe the instrument dry with a dry cloth or tissue. If it is wet when it is used, a false reading may be obtained.

When sugar sand (calcium malate) coats the instrument, clean the instrument with vinegar or scrape with a razor blade. Never use emery or sand paper in cleaning these instruments.

Never allow the instruments to freeze in syrup, sap or water when they are left in the cup.

THE REFRACTOMETER

The refractometer is a delicate optical instrument that can quickly measure the density of maple syrup. The main advantage of using a refractometer is that it requires only a small drop of maple syrup to make an accurate measurement of its density.

The refractometer operates on the principle that light refracts (changes its direction) when it travels through a glass prism covered by a layer of maple syrup. The amount of refraction depends on the density of the syrup.

Calibrating

A correct density reading of maple syrup depends on a proper calibration of the refractometer. Calibration is probably the most important aspect of using a refractometer, and should be done immediately before the first density reading and must be checked regularly for consistency. The calibration of a refractometer may change after the instrument has been laid down several times on a hard surface or if it is exposed to great temperature changes or vibrations.



Figure 5. Spread the oil or syrup sample evenly across the glass prism with a plastic rod or stir stick.

When calibrating a refractometer, clean the glass prism with rubbing alcohol. Never wipe the prism dry — allow it to dry by evaporation. Place a drop of calibration oil on the clean prism. Spread the oil evenly with a plastic rod or stir stick (Figure 5). Do not use glass or metal rods, as these will scratch the surface of the prism. Close the cover and apply a slight pressure on the cover with a finger to spread the oil evenly. Look through the eyepiece toward a light source (Figure 6), such as a light bulb or a bright window. You will see a shadow or dark area on the scale of the instrument. If the scale is out of focus, turn the eyepiece until the scale becomes clearly visible to the eye.

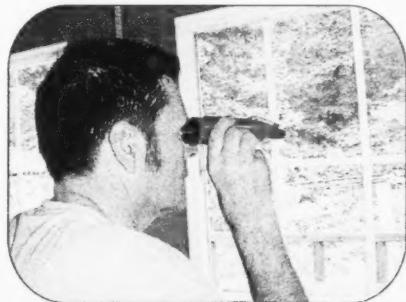


Figure 6. Close the cover and apply a slight pressure on the cover with a finger to spread the oil or syrup sample evenly. Look through the eyepiece toward a light source, in order to read the Brix scale.

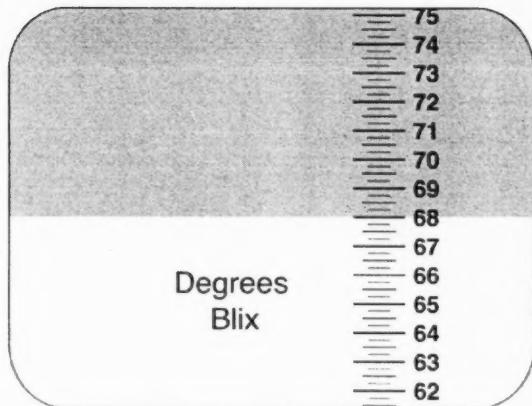


Figure 7. View through eyepiece of refractometer.

The boundary line commonly called “shadow-line” divides the field of view into a bright area and a shadow area. Where the shadow-line crosses the scale, the density can be read in percent sugar or degrees Brix (Figure 7). The shadow-line of the calibration oil will show, for example, 66.1°Brix at 20°C. If the density is not reading 66.1°Brix at 20°C, adjust the instrument by turning an adjustment screw just behind the eyepiece. For best results, calibrate the instrument and the oil both at the same room temperature of 20°C.

Measuring the density of maple syrup

Place a drop of maple syrup on the clean prism. Close the cover and observe the reading (shadow-line). If the air temperature in the room where the syrup is tested is 20°C, the observed reading is the actual density of that sample of maple syrup. If the air temperature in the room is above 20°C, the observed density reading is less than the true density value. Consequently the density reading must be corrected by adding a correction value to the observed reading. If the air temperature is less than 20°C, the observed density reading is higher than the true density value. Consequently the density reading must be corrected by subtracting a correction value from the observed reading in order to obtain a true density value. The correction value to add or subtract can be found in Table 2.

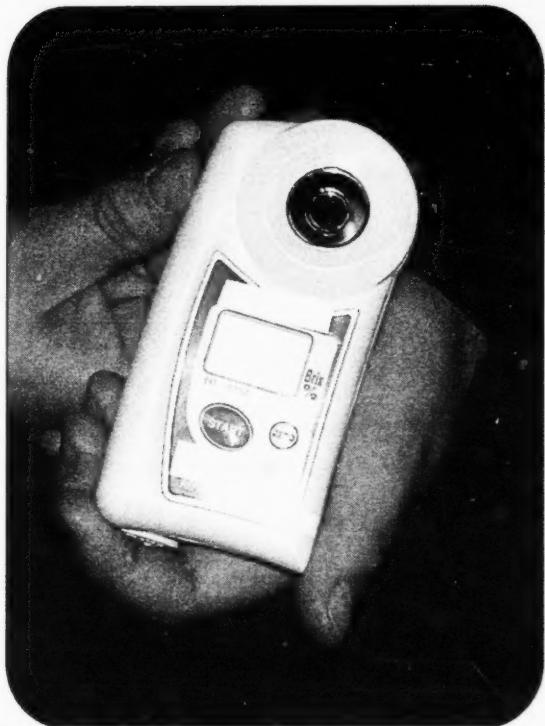


Figure 8. A digital refractometer.

There are refractometers available with built-in temperature correction thermometers. The values on the indicators are similar to the values found in Table 2, and should be directly added to or subtracted from the observed reading. Small hand-held digital refractometers (Figure 8) are also now available to maple syrup producers. Manufacturer's instructions must be closely followed when using these units.

HOW TO AVOID DOUBLE SHADOW-LINES WHEN MAKING DENSITY MEASUREMENTS

The refractometer is commonly used to spot check the syrup when it comes from the finishing pan. Hot syrup applied directly to a cold instrument will not give a distinct shadow-line and may damage the prism.

When a drop of hot or warm syrup is applied to a refractometer prism that has a temperature of 10°C or more cooler than the sample of syrup, the drop of applied syrup will cool rapidly. As the drop of syrup cools to the temperature of the prism, a layering of different densities occurs of the liquid, producing multiple shadow-lines, which cannot be read accurately. It is, therefore, important to take the following steps when checking hot syrup.

First, cool the sample of syrup to a temperature of 65°C (150°F) before it is applied to the refractometer prism. To do this quickly, place the hot syrup in a 10 mL (half ounce) salad dressing cup in the snow. Stir the syrup sample in the cup for about 5 seconds. Secondly, using a plastic stir stick smear the drop of syrup on the prism for about 15 seconds before closing the cover. This stirring will create a homogeneous layer of syrup, which will provide a single and clear shadow-line. After a drop of syrup has been tested, the refractometer should be cleaned by wiping the syrup off the glass prism with soft tissue paper and cleaned with rubbing alcohol.

Calibration oil is available from some maple syrup equipment dealers. Check the label for its correct calibration density.

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